Menlo Park Notebook #226 [N-81-06-22]

This notebook covers the period June-August 1881. The entries are by Charles L. Clarke and consist of notes, calculations, and drawings relating to motors and dynamos. The label on the front cover is marked "Motors" and is stamped "Charles L. Clarke." The book contains 274 numbered pages.

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X E-172 N-81-06-22

Clarke
June 22, 1881

Suppose that a $\frac{14}{100}$ ohm dynamo gives 110 volts at 1200 revolution. Then to return $\frac{9}{10}$ of the energy developed in armature as a motor ($\frac{1}{10}$ being lost as heat and there being 110 volts on the line) the counter E.M.F. must be $\frac{9}{10}$ of 110 volts = 99 volts and active E.M.F. = 11 volts.

The amount of work returned by motor will be

$$\frac{99 \times 11}{.14} \times 44.3 = 3445.91 \text{ ft. lb.}$$

$$= 10.44 \text{ H. P.}$$

To give three horse power it would require a resistance of

$$R = \frac{99 \times 11 \times 44.3}{99000}$$

$$= .4873 \text{ ohms.}$$

With the regular $\frac{14}{100}$ ohm dynamo the value of 1st of cutting wire at 1000 ft. cutting speed per minute is .24 volts taken on the Bar of calculation line with a product of current by turns on magnet equal to 4700.

If armature is five inches in diameter at 1800 revolutions per minute the cutting speed will be

$$\frac{3.1416 \times 5}{12} \times 1800 = 2356 \text{ feet}$$

and the value of 1st of cutting wire =

$$.24 \times 2356 = .5655 \text{ volts}$$

and for 99 volts counter E.M.F. the requisite length of cutting wire is

$$99 \div .5655 = 175 \text{ feet.}$$

Chester, June 23 1881

To have a resis. of .9873 ohm one side of the armature of 175 ft. length should have a resis. of .9746 ohms

$$.9746 = \frac{10.64 \times 175}{m}$$

$$\text{cir. mils} = \frac{10.64 \times 175}{.9746}$$

$$= 1910 \text{ cir mils.}$$

or /wire = .0437" diam.

Carpenter

This is without counting in the winding on the ends, which will add to the resistance. See page 13

~~Take No. 18 B.W.G = $\frac{49}{1000}$" as a basis for calculation. with double covering the size will be .059"~~

Clarke, June 23, 1884

With 10 inches of cutting face suppose armature.
With this length of wire there would be required

$$\cancel{175 \cdot \frac{10}{12} \cdot x}$$

$$x = \frac{175 \times 2}{\frac{10}{12}}$$

$x = 420$ turns of wire

Call it 425 turns with 25 commutator blocks
Then there will be 50 divisions.
With diam of 5", circumference is 15.7 and with 50 divisions and $\frac{1}{32}$" separation the available circumference is 14.14" = .283" for each division

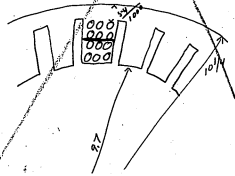
Clarke, June 23, 1891

There will be 9 wires in each division with covering ~~[illegible]~~ and wire = .05" diam. which admits of 5 wires on bottom layer and four top

O diam. = .059

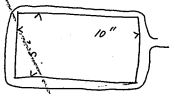
Usually fs-in. .859 × 1-4 .291

The regular $\frac{14}{100}$ hm dynamo has the following construction



O diam. = .057

Clarke
June 23, 1887



The entire length of wire for one turn will be 30" =

2.5 ft.

and for 425 turns =

1062.5 ft

The resis. of wire of this length and $\frac{49}{1000}$" diam. will be

$$R = \frac{10.64 \times 1062.5}{(49)^2}$$

$= 4.7$ ohms

but halved and in multiple arcs $= \frac{4.7}{4} = 1.175$ ohms.

This is much too high.

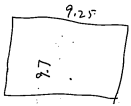
~~Let us take the wire which is $\frac{58}{1000}$ diam. (No. 17 B.W.G.)~~

~~The resistance wire be~~

$$\cancel{R = \frac{10.64 \times 1062.5}{4 \times (58)^2}}$$

~~R =~~

Clarke. June 24 1881



The armature of a $\frac{14}{100}$ ohm dynamo has 37.9" of wire for one turn and for 75 turns there are 236.9 ft.

(× 37.5) Jehing Sanke number

In practice, however, with $\frac{14}{100}$ ohm dynamo it is:

found that the length by calculation is

$$L = \frac{(42)^2 \times 6 \times .28}{10.64}$$

$$L = .287 \text{ feet-}$$

then being 6 strands of $\frac{42}{1000}$ wire.

The length on the face is 18.5 and for 75 turns (x 3 x 2 being double around) is 115.6 feet- leaving by calculation by measured distance 121.3 feet- and by calculation by measured resistance.

171.4 feet, a difference for the ends of 50.3 ft. which is an addition of 41% to the distance taken from measured distance

and is due to the winding at the ends being curved over the shaft.

The ~~dyno~~ motor in question has an armature 6" diameter and 10" face.

To get 175 feet of cutting wire it is necessary to have a number of layers of wire in series on the face of the armature equal to

$$\frac{12 \times 175}{10} = 210$$

~~and to do this there will be required 105 turns~~

~~Make it 108 turns and if there are 6 turns to one commutator there will be 18 commutators.~~

The additional length due to ends for one turn will be 10" and for 108 turns equal to 1080" to which add 417. the length is 1522.8" =

127 ft.

Total length is

127 + 175 =

302 ft.

This should have a resistance of .9746 ohms.

$$.9746 = \frac{10.64 \times 302}{m}$$

$$m = 3297$$

$$\text{diam} = \sqrt{3297} = .057''$$

The nearest B.W.G is No. 17 = .058

Charles June 25. 1841

With 10 strands to a commutator the number of commutators will be 21.

On the ends the additional length due to the larger on face will be 5" and for 210 lengths will be 1050" to which add

41% = 1480" = 123 ft.

Making a total of 175 + 123 = 298 feet.

This should have a resistance = .9746 ohms.

$$.9746 = \frac{10.64 \times 298}{m}$$

$m = 325.3$

diam. = .057"

The nearest wire is $\frac{58}{1000}$"
= No. 17 B.W.G.

Circumference of armature
15." 708

Make the insulation $\frac{15}{1000}$"
which make total diam of one
strand of wire = $\frac{73}{1000}$"

With 5 strands in bottom layer.
The total number in entire
circumference will be 105 × 2
= 210 And space taken
by same wire be
210 × .073 = 15.33
This will not give space
enough.

Suppose 12 strands to a
commutator and 204 strands
instead of 210, then then

Clarke from 25.18

will be 19 commutators

The total length of wire will be ~~increased~~ decreased from 298 ft. to $\frac{298 \times 210}{290}$

$= 216$ ft.

The resistance will be

$R = \frac{10.64 \times 216}{3364}$

$R = .68$ ohms which is not a deviation from .9746 of much account and leaving a Combi. F.M.F. of 2.970.

Suppose 4 strands and 3 strands deep = total of 12

The total number in bottom layer will be 136 strands

$136 \times .073 = 9.93''$ leaving for separation

$15.705 - 9.93 = 5.778$

or for each $5.778 \div 34 = .17$

Suppose the wire in two layers of 6 strands each, the total number in bottom layer will be 17 X 2 X 6 = 204

204 X .073 = 14.892

leaving for separation

15.708 − 14.892

= .816

.816 ÷ 34 = .024" = each space

by making the insulation $\frac{3}{1000}$ the diam. of wire is

= .071"

204 X .071 = 14.484

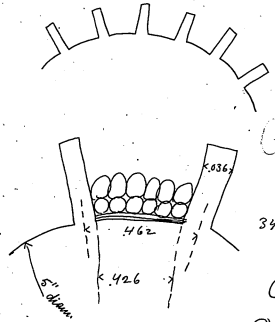
Separating space =

15.708 − 14.484 =

1.224"

and for each

1.224 ÷ 34 = .036" which is sufficient.



O.K.

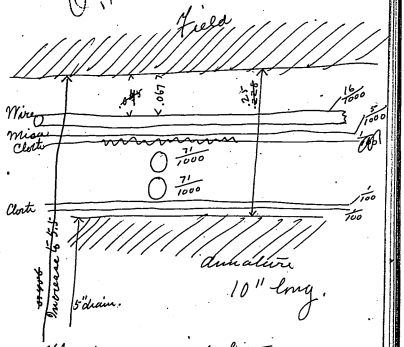
34 divisions

Omit $\frac{88}{1000}$

2 layers of cloth on armature each $\frac{1}{100}$" thick

Omit insulation $\frac{71}{1000}$

O.K.



The space required between magnet and armature is .228 while the calculation was on a basis of .275. This will add 6% to E.M.F. efficiency which is 4% more than the decrease due to shortening length of cutting wire.

Clarke June 25. 1881.

On page three the product of current by turns of wire on magnet must be 4700.

The polar surface exposed to the cutting wire on the armature is in this case one half what it is in the medium machine ($\frac{17}{20}$ thus) and if we use wrought-iron cores, the free magnetism varies as the $\sqrt{\ }$ of the diameter or length therefore $\propto \sqrt{\frac{1}{2}}$.

The medium dynamo has 6" diam. 36" length. Let x be the product of diam. and length of core needed which will give half the free magnetism.

$$2 : \sqrt{72} :: 1 : \sqrt{x}$$

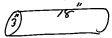
$$2 : \sqrt{6 \times 36} :: 1 : \sqrt{x}$$

$$\sqrt{x} = \frac{\sqrt{216}}{2}$$

$$x = \frac{216}{4}$$

$$x = 54$$

Two convenient factors are 3 and 18



and magnetizing power = 4700

If made of cast iron the value of free magnetism is but $\frac{2}{3}$ that for wrought iron for same magnetizing power.

This being the case there must be an increase of 50% for a motor of cast-iron.

We have then the proportion

$$2 : \sqrt{27} :: 1.5 : \sqrt{x}$$

$$\sqrt{x} = \frac{1.5\sqrt{216}}{2}$$

$$x = \frac{486}{4}$$

$$x = 121.5$$

Two convenient factors are 4.5" X 27".

If we add 25% to the magnetism we should have

$$2 : \sqrt{27} :: 1.875 : \sqrt{x}$$

$$x = 189$$

Two convenient factors are 6" x 31"

6" diam. of core gives
1.5 ft length of one turn.

If No. 20 B.W.G $\frac{31}{1000}$" diam.
it takes 118.5 feet to the ohm
Therefore 79 turns
With 90 ohms resistance there
will be 7110 product
and with 100 volts a current
of 1.1 webers and magnetizing
power of 7821 ~~[illegible]~~.

$$\text{Foot-lbs.} = \frac{100^2 \times 44.3}{90}$$
$$= 5000 \text{ ft. lbs.}$$

Weight of 90 ohms of wire
$= 39.5$ lbs.

Clarke Aug 2. 1881.

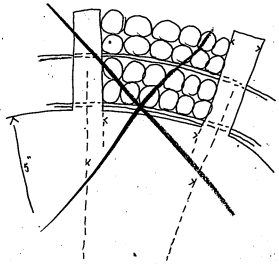
If wire .19 - $\frac{92}{1000}$" is taken
there are 170.7 feet per ohm
and 113 turns

With 90 ohms the product
will be 10170 and
magnetizing power
= 1.1 × 10170
= 11187.

Foot-lbs. with 100 volts.
$\frac{100^2 \times 44.3}{90}$ = 5000.

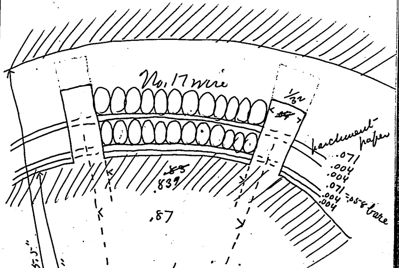
Weight of 90 ohms of this wire
= 82 lbs.

For testing the 3 H.P. motor it is decided to wind ~~it with~~ the armature with No. 19 wire.



Clarke Aug 4, 1881.

O.K.



18 divisions,
36 coils with
12 turns in each coil.